



Dynamic Weather Routes (DWR)

What's the Problem? Severe thunderstorms are the leading cause of delay in US airspace. When such weather is present or forecast on preferred flight routes, weather avoidance routes are selected, usually 1-2 hours before takeoff, and often include large buffers to forecasted weather. As flights progress, airline dispatchers and Federal Aviation Administration (FAA) traffic managers strive to find improved routes to reduce delay. However, operators are especially busy during weather events, and workable opportunities for more efficient routes around bad weather are missed. Automation does not exist to indicate when weather avoidance routes have become stale and could be updated to reduce delay.

What's NASA Doing to Help? NASA has developed a ground-based automation system called **Dynamic Weather Routes (DWR)**. DWR continuously and automatically analyzes in-flight aircraft in en route airspace to find opportunities for time- and fuel-saving corrections to weather avoidance routes. Route corrections are simple route changes like those typically used in today's operations.

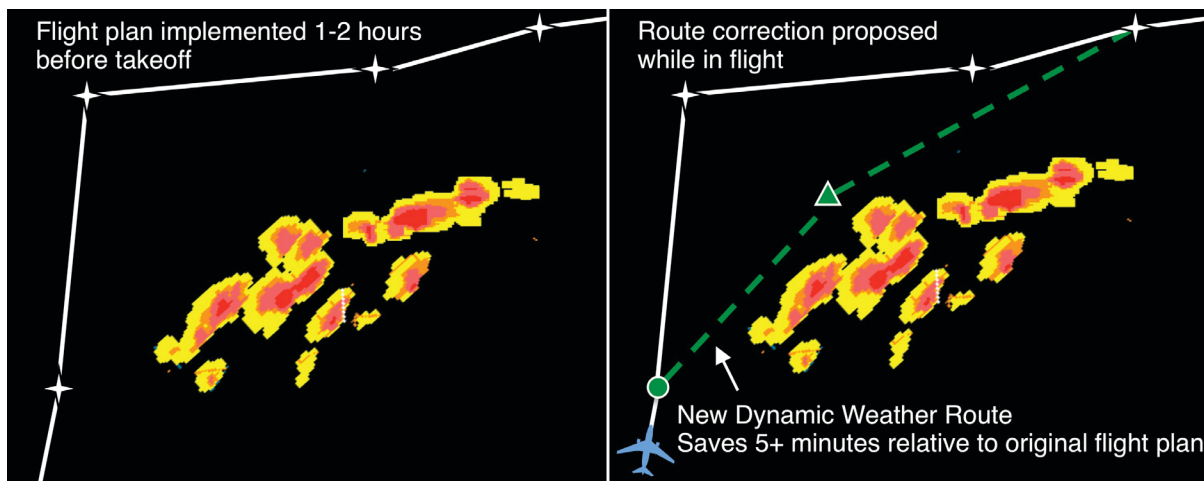
Every 12 seconds, DWR computes and analyzes trajectories for en route flights. DWR first identifies flights that could save 5 or more flying minutes (wind-corrected) by flying direct to a downstream "return" fix on their current flight plan. Eligible return fixes are limited so as not to take flights too far off their current route or interfere with arrival routings near the destination airport. Usually such direct routes that can save 5 or more minutes are due to route segments included to avoid weather. Using the direct route as a "reference route," DWR inserts up to two auxiliary waypoints as needed to find a minimum-delay route correction that avoids the weather, or optionally weather and traffic conflicts, and returns the flight to its planned route at the downstream

fix. If a route correction is found that can save 5 minutes or more relative to the current flight plan, the flight is posted to a list displayed to an airline or FAA user. Auxiliary waypoints are defined using fix-radial-distance format, but a "snap-to" option utilizes nearby named fixes for ease of use in today's operations. Users may adjust the alert criteria, nominally set to 5 minutes, based on their workload and desired potential savings for their flights.

In addition to the primary en route Center traffic data input to DWR, national traffic data are used to probe DWR-advised routes for downstream sector congestion on both the existing flight plan and the DWR routes. DWRs are also tested for conflicts with special use airspace and for FAA route restrictions.

A graphical user interface enables users to visualize proposed routes on a traffic display and modify them if necessary using point, click, and drag inputs. If needed, users can adjust the return fix, auxiliary waypoints, and the maneuver start point. Metrics, including flying time savings (or delay), proximity to current and forecast weather, downstream sector congestion, traffic conflicts, and special use airspace conflicts all update dynamically as the user modifies a proposed route.

Potential Benefits. An analysis of all Fort Worth Center traffic in 2013, excluding arrivals to the major Dallas airports, Dallas-Fort Worth International (DFW) and Dallas Love Field (DAL), indicates a potential savings of about 100,000 flying minutes for 15,000 flights, or about 6.7 minutes/flight on average. These potential savings are over and above the savings flights achieve today through normal pilot requests and controller clearances without DWR. On heavy weather days the potential savings for some DWR routes can range from 20 minutes to over 40 minutes for an individual flight.



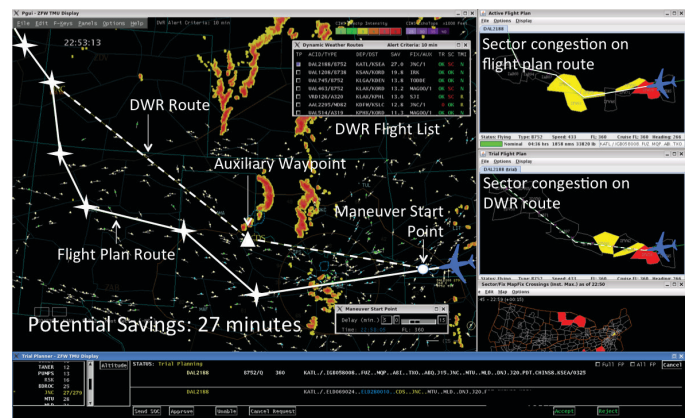


DWR user display at American Airlines Integrated Operations Control Center, Fort Worth, Texas.

Evaluation at American Airlines. Since July 2012, DWR has been in operation at the American Airlines (AA) Integrated Operations Control Center in Fort Worth, Texas, where NASA and AA are conducting an operational evaluation of DWR. Testing is currently limited to AA flights in Fort Worth Center airspace, and since May 2014, AA flights in Fort Worth Center plus its first-tier adjacent Centers (Kansas City, Memphis, Houston, and Albuquerque). A DWR display runs at the Air Traffic Control (ATC) Coordinator Desk where an audible alert sounds when a new AA flight is first posted to the DWR Flight List. An AA ATC coordinator evaluates the proposed route and consults with the dispatcher responsible for the flight. If both agree, the ATC coordinator clicks an “Accept” button on the DWR user display, and the dispatcher sends the proposed route correction to the flight crew (via the Aircraft Communications Addressing and Reporting System, or ACARS). The flight crew evaluates the route change and, if they concur, requests the route change from air traffic control, using today’s normal procedures.

Results. Test results for the period Jan 2013 through Sept 2014 show that 65% of routes advised by DWR and evaluated by AA users were rated acceptable. Potential savings for the DWRs rated “Accept” totaled 8,866 flying minutes for 1,311 flights, and feedback from AA users indicates that ACARS messages with proposed route changes were sent to about 90% of these flights. An analysis of actual Center route amendments indicates an estimated actual savings of 3,290 minutes for 526 AA flights, or 37% of attempted savings.

These savings achieved during voluntary testing by AA are significant, but actual savings are projected to be quite a bit higher. For example, due to staffing limits during the testing phase, only 22% of DWR advisories were evaluated by AA users. Some of the DWR advisories were rejected due to close proximity to weather or merging arrival streams, as well as workload required due to inter-Center coordination. DWR is being further developed to address these problems in order to increase its usage and potential savings. Air/ground



Graphical user interface showing a trial Dynamic Weather Route (DWR)

data communication (Data Comm) and other automation to streamline route change coordination could also significantly improve actual DWR savings.

It is known that some flights get some percentage of potential DWR savings today, without DWR, through normal pilot requests and controller clearances. An analysis of 1,118 AA and non-AA flights over 29 heavy weather days was conducted to estimate how much more savings AA flights get when DWR is used vs. when DWR is not used. Results show that AA flights where DWR was used realize 20% more savings relative to AA and non-AA flights where DWR was not used. Total advised savings for AA flights over the 29 days was 5,417 minutes for 526 flights. Assuming a 20% net savings and an operating cost of \$100/minute, this equates to about \$100,000 net savings in operating costs for one airline in one Center over 29 days.

A sector congestion analysis compared the total time sectors in five Centers (Fort Worth Center plus its first-tier adjacent Centers) spent in Monitor Alert congestion status under two traffic scenarios. Under the baseline scenario, all flights fly their nominal weather avoidance routes. Under the DWR scenario, all flights for which DWR advisories were computed fly their DWR routes. Results, based on analysis of traffic on 30 heavy-weather days with DWR advisories for 7,098 flights, show that the total time all sectors spend in congestion status is reduced by 19% under the DWR scenario relative to the baseline.

Next Steps. AA feedback has been favorable, and other airlines, aerospace companies, and the US Air Force have expressed interest in the DWR concept and software. NASA is supporting technology transfer of DWR for commercialization, and DWR automation is being leveraged to find common route corrections for groups of flights, including arrival streams merging and descending into the terminal area.

For more information on Dynamic Weather Routes (DWR) please visit:

www.aviationsystems.arc.nasa.gov.

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